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ITEM OF INTEREST

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SUBJECT: Soviet Recomputation of the Lateral Photovoltaic Effect

SOURCES:
1. Taubkin, I. I., and A. I. Frimer. On the calculation of the lateral photoeffect photocell. Radiotekhnika i elektronika, v. 7, no. 7, 1962, 1196-1205. (S/109/62/007/007)
2. Wallmark, J. T. Photocell measures light direction. Electronics, v. 30, no. 7, 1 Jul 1957, 165-167.
3. Lucovsky, G. Photoeffects in nonuniformly irradiated p-n junctions. Journal of Applied Physics, v. 31, no. 6, Jun 1960, 1089-1095.

The lateral photoeffect photocell was first described in 1957 by J. T. Wallmark of RCA [2], who suggested that the accuracy attainable with it (better than 0.1 seconds of arc, superior to any similar optical instrument) might lead to military and other applications as a high-precision direction finder. Such a device would be based on the additional photovoltage which occurs parallel to the plane of the p-n junction in nonuniformly illuminated cells. This additional lateral photovoltage falls to zero if the light is focussed by a lens onto the center of the cell, and rises if the light spot is moved away from the center, becoming positive on one side of the cell and negative on the other. It should therefore be possible to determine the direction of the light source by means of a voltmeter connected between the two base contacts. The accuracy of the proposed instruments would of course depend on the linearity of the lateral voltaic response to the change in position of the light spot. Wallmark obtained an experimental deviation from the straight line not exceeding 1.5% of the maximum signal, and gave a restricted analysis demonstrating the linearity of the response to be theoretically justified.

In a recent Soviet article on the lateral photoeffect photocell, I. I. Taubkin and A. I. Frimer have questioned the correctness of Wallmark's computations and in particular of his linearity characteristics, which are based on the expression

$$U = \frac{\rho_n}{WH_n} I_\varphi x, \qquad (1)$$

where (for the case of a small signal) U -- lateral voltage between an arbitrary point in the junction's n-region and the x-coordinate, or between this point and either side of the cell; W -- width of the wafer; $H_n$ -- thickness of the n-layer; and $I_\varphi$ -- the photocurrent, in this case a negligible value. Taubkin and Frimer maintain this expression to be inadmissible because it applies only when

$$2\,U_{max}\,U_{lat} - U^2_{max} \ll \frac{I_\varphi \rho_n}{W^2 H_n J_s\,\lambda} \qquad (2)$$

where $U_{lat}$ -- lateral voltage at the illuminated point; $U_{max}$ -- maximum lateral voltage on the p-n junction; and $J_s$ -- saturation current density. This inequality is satisfied only in the case of a time-dependent process, which means that Wallmark's expression cannot be used to describe steady-state operation of the photoelement.

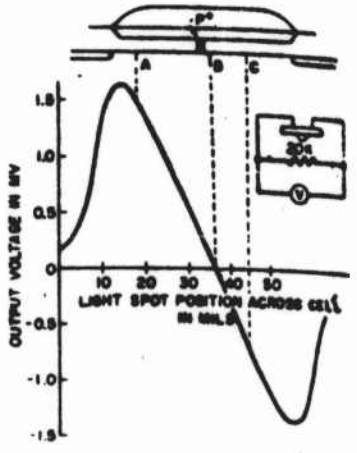


Fig. 1. Lateral photovoltaic effect in relation to light spot position on cell surface according to Wallmark [2[166]]

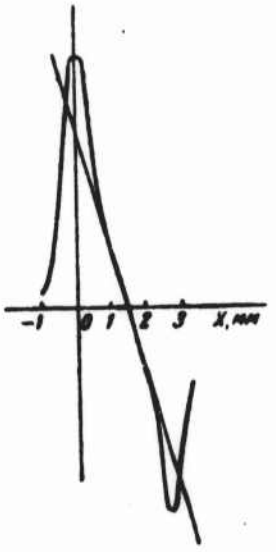


Fig. 2. Lateral photovoltaic effect related to light spot position on cell surface according to Taubkin and Frimer [1[1204]]

Taubkin and Frimer replace Wallmark's approximation with a more rigorous theoretical explanation of the lateral photoeffect which incorporates the lateral fall-off parameter introduced by Lucovsky [3]. They

give computations for both small and large signals which show that the linearity of the response holds only for very low illumination. This implication that the chief condition for the high accuracy of Wallmark's proposed instruments is not met finds support in their experimental curves (Fig. 2, above), which appear to agree fully with their analytical predictions. The linearity of the lateral output voltage response shown in Wallmark's curve (Fig. 1) is contradicted by the nonlinearity of the lateral short-circuit current response shown in Taubkin and Frimer's curve (Fig. 2).